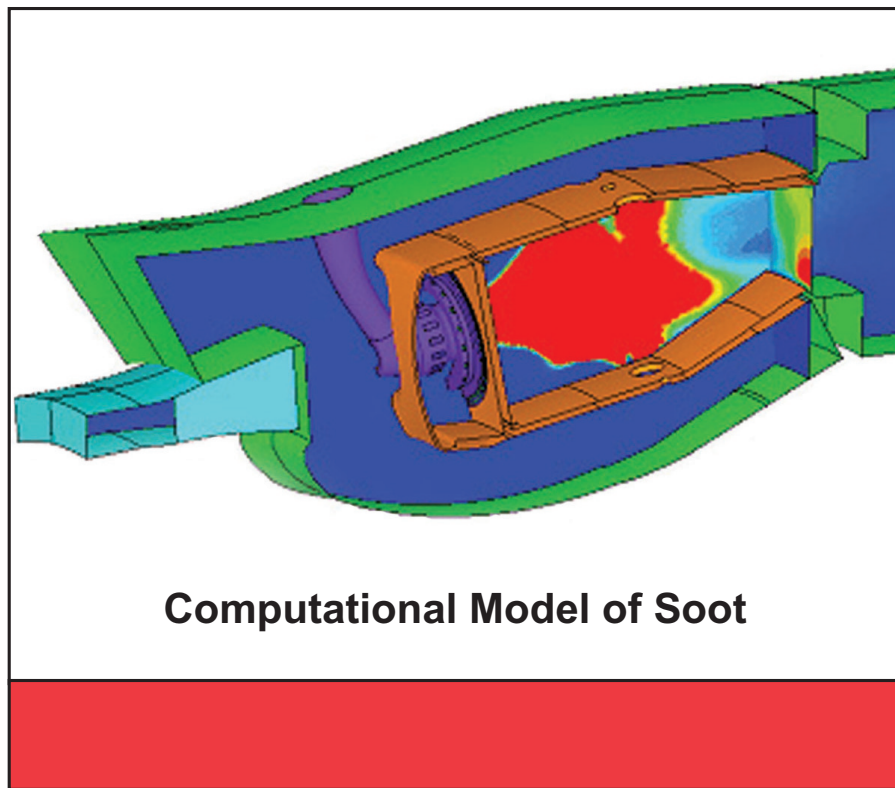


Air Force Research Laboratory | AFRL

Science and Technology for Tomorrow's Aerospace Forces

Success Story

IMPROVED JET ENGINE DESIGN FROM SOOT RESEARCH



The Air Force Office of Scientific Research (AFOSR) supported research that produced a computational model for the prediction of soot emissions from gas turbine combustors. This technology led to improved jet engine design, resulting in significant advancements in environmental emission standards.



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Emerging Technologies

Accomplishment

Under AFOSR's Aerospace and Materials Sciences Directorate support, Dr. Meredith B. Colket III, of United Technologies Research Center (UTRC) in East Hartford, Connecticut, along with Mr. Robert J. Hall of UTRC, and Professor Mitchell D. Smooke of Yale University, formulated a dual-phase model for soot production. This model incorporates (1) gas-phase chemistry to describe the progressive growth of gaseous hydrocarbon molecules to form incipient soot particles, and (2) aerosol dynamics to predict the agglomeration of these initial soot particles into larger particles found in engine combustor environments.

Background

Arguably, emissions represent the most stringent test of engine design capability. Turbine engines produce trace amounts of soot and nitrogen oxide emissions in combustors relative to the mass flow rates of fuel and air. However, these small amounts can cause serious damage to engine components, and are stringently regulated due to their adverse environmental impact.

Engine manufacturers, such as Pratt and Whitney, face these challenges for both military and commercial engine designs. For example, Pratt and Whitney's 2037 engine, used for commercial transportation systems like the Boeing 757 aircraft, is also the basis for the F117 engine that propels the Air Force C-17 cargo plane.

Computational tools are essential elements of gas turbine design as the only cost-effective means to achieve preeminent design objectives. However, because of limitations in both computational capability and basic physical understanding, computational design methods were limited to qualitative screening of alternative combustor configurations.

Future Department of Defense performance requirements, as elucidated in the advanced phases of the Integrated High Performance Turbine Engine Technology and the Versatile Affordable Advanced Turbine Engine programs, will necessitate new designs that will surpass evolutionary strategies relative to current engine designs. AFOSR research addressed both computational software and physicochemical deficiencies in order to produce quantitatively accurate computational design methodology.

Dr. Saadat Syed, a Pratt and Whitney Fellow in combustion, recognized the accuracy and computational efficiency of this model and incorporated a streamlined version into the design methodology for the Pratt and Whitney 6000 aircraft engine. Based on the test results, Pratt and Whitney projects this engine to comply fully with existing International Aviation Organization emission standards.

Additional information

To receive more information about this or other activities in the Air Force Research Laboratory, contact TECH CONNECT, AFRL/XPTT, (800) 203-6451 and you will be directed to the appropriate laboratory expert. (01-OSR-09)